

Ukrainian Synchronous Network of small Internet Telescopes as rapid action instrument for transient objects

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Abstract

UNIT (The Ukrainian synchronous Network of small Internet Telescopes) is a system of automated telescopes that search for simultaneous optical activity of transient objects associated with variable stars, small bodies of the Solar system, Near-Earth objects (NEOs), gamma ray bursts, etc. Their instruments are sensitive down to $M_V \approx 18$ and require an average of 60 seconds to obtain the first images of the transient events after the alarm or GCN notice. Telescopes of UNIT are equipped with fast CCD cameras to study astrophysics on the timescales up to tens Hz. UNIT will be operating by the middle of 2008.

keywords instrumentation: photometers – instrumentation: detectors – methods: observational – techniques: photometric – telescopes

1 Introduction

The philosophy of UNIT is to develop an instrument allowing to obtain observations through the Internet from a PC at any location. UNIT is primarily supposed for professional applications. It can also be employed for educational aims by students via a www gateway. The foundation of this project must be the ideas of high technology, innovative methods of observations and data processing, know-how. Just such approaches allow the project will be able to survive in the conditions of high competition in the world scientific community. A typical station of the Network is as follows: standard equipment + trained operator + Internet. Correspondents and participants of the Network can be organized in any country of the world, including the Ukrainian station in Antarctic Continent.

2 Instrumentation

UNIT consists of two observational complexes in Ukraine and Russia (Peak Terskol, North Caucasus) complete by small Celestron robotic telescopes with aperture 11 and 14 inches. We will use frame-transfer CCDs as the detectors for UNIT. The cooled chips have imaging areas of 1024x1024 and 512x512 pixels with resulting dark current of 0.5 e-/pixel/s. For small windows it is possible to take 0.01 s exposures. UNIT uses GPS technology to take the pointing, guidance and observations in the synchronous operating mode. Using GPS receiver, we will synchronize all exposures with two remote UNIT telescopes to an absolute accuracy of better than 1 millisecond. We will use the UBVRI filter-set.

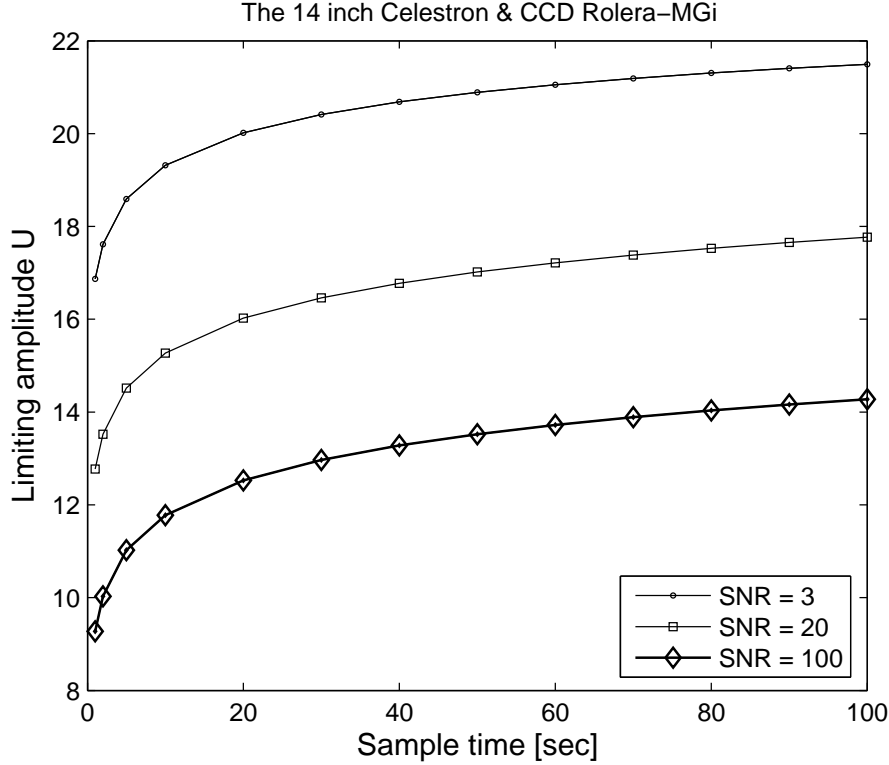


Figure 1: Under average conditions, i.e. seeing of ~ 1 arcsec, 2 min exposure a detectable magnitude is around $U \sim 21$. It is possible to measure stars up to 18 mag with the 5% precision. Stars of around 12 mag can be measured with the 1% precision with 10 sec exposure. Practical measurements at Peak Terskol (M. Andreev) fully coincide with theoretical estimations.

3 Data acquisition

The CCD software operates on Windows-based systems and gives complete control over the image capture functions. The data is transferred to a PC via a PCI bus (CCD47-10 AIMO Back Illuminated Compact Pack High Performance CCD Sensor) and via an IEEE 1394 (FireWire) digital interface (the Rolera-MGi camera). The UNIT telescopes run under local operator control. Observer communicates with operator using the VoIP technology of real-time talk/call transmissions through data networks. He conducts vocal or video conversation, using connected to the computer microphone, loud speaker and webcam. He can utilize the hand-written input for writing of instantaneous reports through data network too.

4 Performance

Figure 1 shows the limiting U magnitudes for detection with UNIT at a signal-to-noise of 3/20/100 as a function of exposure time. Figure 2 shows the limiting U magnitudes for fast photometry with the 14 inch Celestron.

5 Science

Foremost advances in astronomy can result when a new idea becomes accessible for implementation. Distinctive feature of UNIT consists in synchronous operation of several far remote telescopes based on the robotic instrumentation. This allows

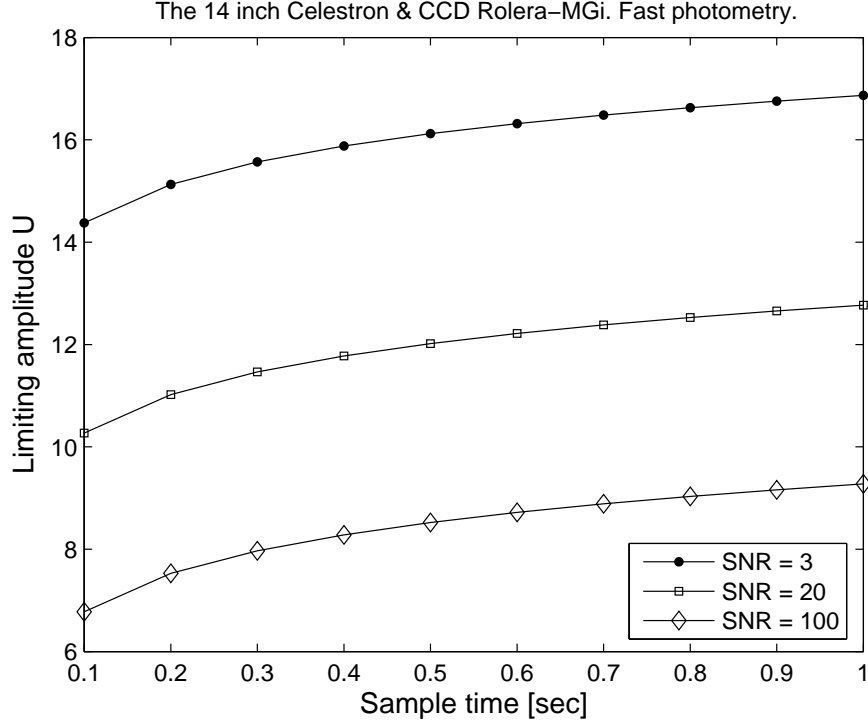


Figure 2: Under seeing of ~ 1 arcsec it is possible to carry out fast stellar photometry within 5-50 Hz for stars of 10-13 magnitudes with the precision of 10-20%. Practical measurements with the 11 inch Celestron at Peak Terskol proved that we could pick a detectable magnitude 17.5 with 2 sec exposure. It is close to the theoretical estimations.

studying wider class of problems at other viewing angle. Studies of variables which are 12 mags in quiescence on timescales of a second could be accomplished with UNIT. We can use the coincidence technique with the remote UNIT telescopes operated synchronously in order to obtain the time resolution about 0.1 s, when studying transients, which are typically 10-14 magnitudes. We can perform follow-up observations of GRB optical-counterparts down to 18 magnitudes. The UNIT telescopes are planned to be supplied with a low resolution optical spectrograph (the resolving power ~ 100) for time-resolved spectrography. This permits studying short-time variations on timescales of seconds for stars of 10 magnitudes both in a continuous spectrum and spectral lines simultaneously. UNIT has a mission to work on around a dozen science programs:

1. the activity of comets;
2. searching for new asteroids, detection of NEOs, space debris;
3. wide range of observing programs including the fast variability in light and spectra from the various types of variable stars and centers of active galaxies, asteroseismology;
4. the remotely operated long-term Stellar Flare Monitor;
5. follow-up observations of GRB optical-counterparts;
6. searching for newly discovered Novae and Supernovae, etc.

5.1 Some comparisons

- (1) TAROT are robotic observatories devoted to measure the early optical counterparts of gamma-ray bursts [1]. TAROT observe with no human in-

teraction. TAROT are two identical 25 cm telescopes $F/D = 3.4$ that cover $1.86^\circ \times 1.86^\circ$ field of view on the Andor CCD cameras (Marconi 4240 back illuminated). Spatial sampling is 3.3 arcsec/pix. Six filters are available : BVRI, a clear filter and a 2.7 density coupled to V (for Moon and planets). Detection limit is about $V=17$ in 1 min. exposure. TAROT Calern observatory in France: $lon = 6.9238^\circ$ E, $lat = 43.7522^\circ$ N, $alt=1270$ m. TAROT La Silla ESO observatory : $lon = 70.7322^\circ$ W, $lat = 29.2608^\circ$ S, $alt = 2347$ m.

- (2) Full automated Internet-telescope MASTER, Russia, Near Moscow, Alexander Krylov Observatory, Sternberg Astronomical Institute [2]. Modified Richter-Slefogt Camera, $D = 355$ mm, $D/F - 1:2.4$, Flat FOV - $5^\circ \times 5^\circ$. CCD-camera AP16E (4000x4000). On optical observations of GRB: GRB040308 (GCN 2543) - 48 h after trigger time, OT limit 21.2 mag .

5.2 Comparison with ULTRACAM

ULTRACAM is an ultra fast camera capable of capturing some of the most rapid astronomical events [3]. For comparison we employ analogical results for the limiting magnitudes with ULTRACAM (at a signal-to-noise of 10) as a function of exposure time at the GHRIL focus of the 4.2-m William Herschel Telescope (WHT) on La Palma. Difference between both our calculations and practical measurements and of the ULTRACAM data is explained only by a geometrical factor - different diameters of telescopes - and equals about 4 magnitudes (15 / 11 mag for the 0.1 s time resolution and 13 / 9 mag for the 0.01 s one).

Acknowledgement

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